AMENDMENTS TO THE CLAIMS

The following listing of claims will replace all prior versions and listings of claims in the application.

LISTING OF CLAIMS

1. (previously presented) An electronic control system for use in a riveting process, the system comprising:

an electronic control unit;

an electric motor connected to the electronic control unit;

a first sensor connected to the electronic control unit and the electric motor, the first sensor being operable to indicate at least one of: (a) torque of the electric motor, (b) speed of the electric motor, and (c) an electrical power characteristic of the electric motor; and

at least a second sensor connected to the electronic control unit, the second sensor operably detecting a riveting characteristic occurring during the riveting process, the riveting characteristic consisting essentially of at least one of: (a) riveting force, (b) rivet punch assembly location, (c) rivet size, and (d) workpiece thickness;

the electronic control unit automatically varying the riveting process in a real-time manner in response to output from at least the first and second sensors.

2. (original) The system of Claim 1 further comprising a rivet and a riveting machine which includes the electric motor, the riveting machine operably moving the rivet.

3. (original) The system of Claim 2 further comprising:

a rivet feeder having an actuator connected to the electronic control unit; and

a feed tube sensor connected to the electronic control unit;

wherein the electronic control unit operably controls feeding of the rivet by the feeder during the riveting process and the feed tube sensor sends a signal to the electronic control unit indicative of the presence of the rivet.

4. (previously presented) The system of Claim 1 further comprising a punch and a fluid-free transmission, the transmission being operable to convert rotary motion of the electric motor to linear motion driving the punch, the transmission always being coupled to the electric motor and the punch always being coupled to the transmission during electric motor actuation.

5. (original) The system of Claim 4 wherein the transmission includes a closed loop belt.

6. (original) The system of Claim 1 wherein the riveting characteristic sensed by the second sensor is the riveting force.

7. (original) The system of Claim 1 wherein the riveting characteristic sensed by the second sensor is the rivet punch assembly location.

8. (original) The system of Claim 1 wherein the riveting characteristic sensed by the second sensor is a rivet size.

9. (original) The system of Claim 1 wherein the riveting characteristic sensed by the second sensor is a workpiece thickness.

10. (original) The system of Claim 1 wherein the second sensor is a load cell operably indicating a linearly moving member force.

11. (original) The system of Claim 1 wherein the second sensor is a proximity switch.

12. (previously presented) A riveting electrical control system comprising:

(a) an electrical control unit;

(b) an electric motor connected to the electrical control unit;

(c) a fluid-free transmission operably driven by energization of the electric motor;

(d) a riveting punch operably advanced by the transmission; and

(e) a sensor connected to the electrical control unit, the sensor being operable to sense riveting force.

13. (previously presented) The system of Claim 12 further comprising a rivet operably driven by the punch, the electrical control unit automatically varying a characteristic associated with the punch in response to the sensed riveting force.

14. (original) The system of Claim 13 further comprising:

a rivet feeder having an actuator connected to the electronic control unit; and

a feed tube sensor connected to the electronic control unit;

wherein the electronic control unit operably controls feeding of the rivet by the feeder during the riveting process and the feed tube sensor sends a signal to the electronic control unit indicative of the presence of the rivet.

15. (original) The system of Claim 12 wherein the transmission operably converts rotary motion of the electric motor to linear motion for moving the punch.

16. (original) The system of Claim 15 wherein the transmission includes a closed loop belt.

17. (previously presented) The system of Claim 12 wherein a second riveting characteristic is sensed in real-time for use by the electrical control unit.

18. (previously presented) The system of Claim 12 further comprising a second sensor operably sensing an electrical power characteristic of the electric motor.

19. (previously presented) The system of Claim 12 further comprising a second sensor operably sensing a speed of the electric motor.

20. (previously presented) The system of Claim 12 further comprising a second sensor operably sensing a torque of the electric motor.

21. (original) The system of Claim 12 wherein the electric control unit is a programmable computer.

22. (previously presented) A riveting electrical control system comprising:

(a) an electrical control unit;

(b) an electric motor connected to the electrical control unit;

(c) a transmission operably driven by energization of the electric motor, the transmission operably converting rotational movement of the electric motor to substantially linear movement;

(d) a riveting punch operably advanced in a substantially linear direction by the transmission;

(e) a self-piercing rivet operably driven by the punch as controlled by the electrical control unit; and

(f) a die operably diverging an end of the rivet without the rivet piercing completely through the exterior surface of a die-side workpiece adjacent the die;

the electric control unit operably controlling energization of the electric motor and operably determining if an undesired riveting condition is present.

23. (original) The system of Claim 22 further comprising a sensor connected to the electrical control unit, the sensor being operable to sense a characteristic of the electric motor, wherein the characteristic changes at least in part due to varying rivet setting performance.

24. (original) The system of Claim 23 wherein the characteristic is an electrical power characteristic of the electric motor.

25. (original) The system of Claim 24 wherein the electrical power characteristic is electrical current.

26. (original) The system of Claim 23 wherein the electrical control unit compares a signal from the sensor to previously stored data.

27. (original) The system of Claim 22 wherein a rotational axis of the electric motor is offset from a centerline coaxial with an advancing direction of the punch.

28. (original) The system of Claim 27 wherein the motor axis is substantially parallel to the punch centerline.

29. (previously presented) The system of Claim 22 wherein the electrical control unit includes a programmable microprocessor which automatically varies a riveting process based at least in part on the determination.

30. (previously presented) The system of Claim 22 wherein the electronic control unit automatically operably causes varying sized self piercing rivets to be operably driven by the punch.

31. (currently amended) The system of Claim 22 wherein the transmission is always coupled to the electric motor, and the electrical control unit transmits an error signal if the undesired condition is present ~~and the transmission is always coupled to the electric motor~~.

32. (original) The system of Claim 22 wherein the electrical control unit stops the rivet process if the undesired condition is present.

33. (original) The system of Claim 22 wherein the electrical control unit determines if a riveting characteristic is within a desired range.

34. (previously presented) A control system comprising:

(a) a programmable control unit;

(b) a riveting machine including an electric motor and a transmission operable to convert rotary motion of the electric motor to linear motion of a punch;

(c) a self piercing rivet operably set by the punch acting with a substantially relatively stationary die of the riveting machine when the control unit causes energization of the electric motor; and

(d) a feeder operable to transfer the rivet to the riveting machine.

35. (original) The system of Claim 34 further comprising a sensor located adjacent the rivet machine, the control unit being operable to receive a signal generated by the sensor.

36. (original) The system of Claim 35 wherein the control unit compares the signal generated by the sensor to previously stored data.

37. (previously presented) The system of Claim 35 wherein the sensor is attached to the rivet machine, the transmission comprises a spindle and a nut enmeshed with the spindle, and the transmission is always coupled to the electric motor.

38. (previously presented) The system of Claim 35 wherein the sensor is operable to indicate a characteristic of the electric motor and the control unit varies the operation of the riveting machine during riveting based at least in part on output from the sensor.

39. (original) The system of Claim 34 wherein the control unit is operable to control actuation of the rivet feeder.

40. (original) The system of Claim 34 further comprising an articulating robot, the riveting machine being attached to and positioned by the robot.

41. (original) The system of Claim 34 wherein the control unit transmits an error signal if an undesired condition is present.

42. (previously presented) The system of Claim 34 wherein the electrical control unit determines if a riveting characteristic is within a desired range, the rivet being of a hollow and diverging type with a solid head.

43. previously presented) A control system comprising:

(a) a programmable controller;

(b) a riveting machine including an electric motor and a transmission always coupled to the electric motor during motor actuation, the transmission being operable to convert rotary motion of the electric motor to substantially linear motion;

(c) a rivet operably moved by the riveting machine when the controller causes energization of the electric motor, the rivet being of a hollow and diverging type with a solid head; and

(d) a sensor operable to indicate power consumption of the electric motor, the controller operably receiving a signal generated by the sensor.

44. (original) The system of Claim 43 wherein the controller compares the signal generated by the sensor to previously stored values.

45. (original) The system of Claim 43 further comprising a rivet feeder connected to the riveting machine, the controller operably controlling actuation of the rivet feeder.

46. (original) The system of Claim 43 further comprising an articulating robot, the riveting machine being attached to and positioned by the robot.

47. (original) The system of Claim 43 wherein the transmission includes an endless belt.

48. (previously presented) A control system comprising:

(a) a programmable controller;

(b) a riveting machine including an electric motor and a transmission, the transmission being operable to convert rotary motion of the electric motor to linear motor, a section of the electric motor being rotatable about an axis offset from a centerline coaxial with an elongated dimension of the punch;

(c) a rivet operably moved by the riveting machine when the controller causes energization of the electric motor;

(d) a sensor operable to indicate a riveting force characteristic, the controller operably receiving a signal generated by the sensor;

(e) an articulating robot, the riveting machine being attached to and positioned by the robot; and

(f) a rivet feeder connected to the riveting machine, the controller operably controlling actuation of the rivet feeder.

49. (previously presented) The system of Claim 48 wherein the controller compares the signal generated by the sensor to previously stored data, and the rivet having a solid head and a diverging open end which does not completely penetrate a workpiece farthest from the head.

50. (previously presented) A riveting electrical control system comprising:

(a) an electrical control unit;

(b) an electric motor connected to the electrical control unit;

(c) a fluid-free mechanical transmission operably converting rotational movement of the electric motor to substantially linear movement, the transmission being coupled to the electric motor during motor use;

(d) a rivet setting punch operably advanced by the transmission;

(e) a substantially stationary die always aligned with the punch; and

(f) the electrical control unit operably determining if a riveted joint is within a desired range.

51. (original) The system of Claim 50 wherein the electrical control unit stops the rivet process if the undesired condition is present.

52. (original) The system of Claim 50 wherein the electrical control unit transmits an error signal if the undesired condition is present.

53. (previously presented) The system of Claim 50 wherein the electrical control unit includes a programmable microprocessor which compares sensed data to other data, and the electrical control unit continuously compares actual workpiece thickness signals to previously stored workpiece thickness signals substantially during rivet setting.

54. (previously presented) The system of Claim 50 wherein the electrical control unit operably determining if a riveted joint is within a desired range

includes determining if a portion of a rivet is essentially flush with a punch-side workpiece outer surface without completely piercing through a die-side workpiece.

55. (previously presented) The system of Claim 48 wherein the controller determines if a head of the rivet is essentially flush with a punch-side workpiece outer surface without completely piercing through a die-side workpiece.

56. (previously presented) A riveting system comprising:

an electric motor;

a rotatable member operably driven by energization of the motor;

a transmission serving to convert rotary motion of the rotatable member to linear motion;

a plunger coupled to the transmission and being movable in a linear direction;

a self piercing rivet operably driven by the plunger, the rivet being at least partially hollow; and

a data monitoring unit electrically connected to at least one of: (a) the motor, and (b) the transmission.

57. (previously presented) The system of Claim 56 further comprising:

a housing surrounding a portion of the plunger;

a die;

a substantially C-shaped frame attaching the die to the housing; and

a workpiece clamp coupled to the transmission and being linearly movable.

58. (previously presented) The system of Claim 57 wherein the plunger and clamp are movable together at a first speed during advancing movement, and the plunger is subsequently movable at a second speed slower than the first speed when the clamp is substantially stationary during rivet-to-workpiece engagement.

59. (previously presented) The system of Claim 56 wherein the transmission includes a circulating ball spindle drive, further comprising a workpiece clamp operably driven by the spindle drive.

60. (previously presented) The system of Claim 56 wherein the motor has a rotational axis offset from an elongated centerline of the plunger.

61. (previously presented) The system of Claim 56 further comprising a punch-side workpiece and a die-side workpiece, the rivet completely piercing the punch-side workpiece but being prevented from completely piercing the die-side workpiece.

62. (previously presented) The system of Claim 56 further comprising:

a sensor connected to the monitoring unit;

the sensor being operable to detect at least one of: (a) clamp travel, (b) plunger advancing force, (c) clamp advancing force, (d) actuator power consumption, (e) actuator torque, and (f) transmission torque;

the sensor operably sending the detected information to the monitoring unit in order to determine the actual riveted joint condition;

a die always aligned with the plunger;

a frame securing the die; and

a robotic arm coupled to the frame.

63. (previously presented) A riveting system comprising:

an electric motor;

a transmission serving to convert rotary motion of the motor to linear motion;

a member coupled to the transmission and being movable in a linear direction;

a self piercing rivet operably driven by the member;

a linearly movable workpiece clamp coupled to the transmission;

the motor having a rotational axis offset from an elongated centerline of the member and the rotational axis of the motor being substantially parallel to the centerline of the member; and

a member-side workpiece and a die-side workpiece, the rivet completely piercing the member-side workpiece but being prevented from completely piercing the die-side workpiece;

the member and clamp being initially movable together at a first speed during advancing movement, and the plunger being subsequently movable at a second speed slower than the first speed when the clamp is substantially stationary during rivet-to-workpiece engagement.

64. (previously presented) The system of Claim 63 further comprising:

a data monitoring unit electrically connected to the motor;

a first sensor connected to the monitoring unit;

the first sensor being operable to detect at least one of: (a) clamp travel, (b) member advancing force, (c) clamp advancing force, (d) motor power consumption, (e) motor torque, and (f) transmission torque;

the first sensor operably sending the detected information to the monitoring unit in order to determine the actual riveted joint condition; and

a second sensor operably detecting a riveting characteristic and sending a corresponding signal to the monitoring unit in a real time, substantially closed loop manner.

65. (previously presented) The system of Claim 63 further comprising a force transducer operable to sense force applied by at least one of : (a) the member, and (b) the clamp.

66. (previously presented) The system of Claim 63 further comprising a displacement transducer operable to sense displacement of the member.

67. (previously presented) The system of Claim 63 further comprising a monitoring unit operably determining the quality of the riveting procedure based on at least the force applied by the member during the riveting procedure.

68. (previously presented) The system of Claim 67 wherein the monitoring unit determines the force of the member based at least on the power consumption of the motor.

69. (previously presented) The system of Claim 63 further comprising a monitoring unit determining the member force based at least on the torque of at least one of: (a) the motor, and (b) the transmission.

70. (previously presented) The system of Claim 63 further comprising a monitoring unit operably determining whether a portion of the rivet is flush with a surface of the member-side workpiece.

71. (previously presented) A riveting control system comprising:

(a) an electric motor;

(b) a transmission operably converting rotary motion of the motor to linear motion;

(c) a plunger coupled to the transmission and being movable in a linear direction;

(d) a rivet operably advanced by the plunger; and

(e) a data monitoring unit operably comparing a characteristic indicative of an actual riveted joint condition to a previously stored value, the monitoring unit operably determining whether a portion of the rivet is flush with a workpiece surface.

72. (previously presented) The system of Claim 71 further comprising:

a first sensor connected to the monitoring unit operable to detect at least one of: (a) plunger advancing force, (b) clamp advancing force, (c) actuator power consumption, (d) actuator torque, and (e) transmission torque; and

a second sensor connected to the monitoring unit operable to detect a riveting characteristic;

the sensors operably sending the detected information to the monitoring unit.

73. (previously presented) The system of Claim 71 further comprising a sensor, the monitoring unit operably determining the riveting force of the plunger based at least on the power consumption of the motor as sensed by the sensor, and subsequent riveting force being varied based on the sensed power consumption.

74. (previously presented) The system of Claim 71 further comprising a displacement

transducer operable to sense displacement of the plunger.

75. (previously presented) The system of Claim 71 wherein the monitoring unit determines the plunger force based at least on the torque of at least one of: (a) the motor, and (b) the transmission.

76. (previously presented) The system of Claim 71 wherein the rivet is a self-piercing rivet which is at least partially hollow, operably driven by the plunger into an imperforated portion of automotive vehicle panels.

77. (previously presented) The system of Claim 71 wherein the rivet is inserted and fully secured by a single and substantially continuous stroke of the plunger, further comprising a substantially stationary die always aligned with the plunger.